SECTION 4

DESCRIPTION OF MODEL MINES

4.0 Description of Model Mines

Section 1.3 describes uranium mines and their operations, and Section 3 describes the potential sources of contamination at the principal types of active and inactive mines. These discussions include an analysis of the potential sources of contamination, quantities of contaminants associated with the different sources, variations in the sources, and estimates of the values needed to define the impact that these sources may impose upon the environment and nearby populations. We attempted to define these terms and mining parameters in a way that would reflect a general view of the uranium mining industry and permit a generic assessment. The parametric values that we have chosen for this assessment are listed below. The sections of this report from which they were derived are given in parentheses.

4.1 Surface Mine

The model open pit (surface) mine will be located in Wyoming. It is the mine defined in Section 3.3 as the "average large mine." However, to define the total impact of all 63 open pit mines operating in the United States in 1978 we used the parameters developed in Section 3.3 for the "average mine."

Production Parameters (1.3.1, 3.3.1)

Parameter	Average Large Mine	Average Mine
Ore, MT/yr	5.1×10^5	1.2×10^5
Sub-ore, MT/yr	5.1×10^5	1.2×10^5
Overburden, MT/yr	4.0×10^7	6.0×10^6

Mining Parameters (3.3.1)

Parameter	Average Large Mine	Average Mine
Mining days per year	330	330
Mine life, yr	17	17
Ore stockpile residence time, days	41	41
Overburden management	Case 2*	Case 2*

*Case 2--Backfilling concurrent with mining - assumes 7 pits opened in 17-yr. mine life and the equivalent of one-pit overburden (2.4 yr. production) remains on the surface.

Ore Parameters (3.3.1.2)

Parameter	Average Large Mine	Average Mine
Average grade, percent U_3O_8	0.1	0.1
Th-232 concentration, pCi/g	10	10
Activity ratio (dust/ore)	2.5	2.5
Mineralogy	Sandstone	Sandstone
Density, MT/m^3	2.0	2.0
Surface area of stockpile, m^2	6,200	3,590
Area of pad, m^2	5,300	3,340
Stockpile height, m	9.2	3.1
Thickness of ore zone, m	12	12

Sub-Ore Parameters (3.3.1.3)

Parameter	Average Large Mine	Average Mine
Average grade, percent U_3O_8	0.015	0.015
Th-232 concentration, pCi/g	2	2
Activity ratio (dust/sub-ore)	2.5	2.5
Mineralogy	Sandstone	Sandstone
Density, MT/m^3	2.0	2.0
Surface area of stockpile, m^2	120,000	36,000
Stockpile height, m	30	30
Area of pad, hectares	11	3

Overburden Parameters (3.3.1.1)

Parameter	Average Large Mine	Average Mine
Average grade, percent U_3O_8	0.0020	0.0020
Th-232 concentration, pCi/g	1	1
Mineralogy	Sedimentary	Sedimentary
Density, MT/m^3	2.0	2.0
Surface area of dump, m^2	1.1×10^6	3.5×10^5
Dump height, m	65	30
Area of terrain, hectares	104	33

Wastewater Discharge Parameters (3.3.2.2)

Parameters (mg/ℓ except as noted)	Average Mine
Discharge volume, m^3/min	2.94 (Assumed value of 3.0)
Total uranium	0.07
Radium-226, pCi/ℓ [a]	0.41
Total suspended solids	20.88
Sulfate[b]	175
Zinc	0.071
Cadmium	0.004
Arsenic	0.005

[a] Concentration of Ra-226 and its daughters are reduced to 10% of the amount actually released due to irreversible sorption and precipitation.

[b] Concentration of sulfate is reduced to 20% of the amount actually released due to irreversible sorption and precipitation.

Airborne Source Terms (3.3.4)

Section 3.3.4 identifies and describes potential sources of airborne contamination at surface mines. The principal sources are dusts produced by mining operations and wind erosion and Rn-222 released by exposed uranium in the pit and overburden, sub-ore, and ore piles. The tables of Section 3.3.4 present the average annual emissions of contaminants from these sources during active mining.

Source	Table
Combustion Products	3.30
Vehicular Dusts	3.32
Dust from Mining Activities	3.33
Wind Suspended Dust	3.34
Rn-222 Emissions	3.35

4.2 Underground Mine

The model underground mine, defined in Section 3.4 as the "average large mine," will be located in New Mexico. However, to determine the total impact of all 305 underground uranium mines in the United States we used the parameters developed in Section 3.4 for the "average mine."

Production Parameters (1.3.1, 3.4.1)

Parameter	Average Large Mine	Average Mine
Ore, MT/yr	2×10^5	1.8×10^4
Sub-ore, MT/yr	2×10^5	1.8×10^4
Waste rock, MT/yr	2.2×10^4	2.0×10^3

Mining Parameters (3.4.1)

Parameter	Average Large Mine	Average Mine
Mining days per year	330	330
Mine life, yr	17	17
Ore stockpile residence time, days	41	41
Waste rock management	No backfill	No backfill

Ore Parameters (3.4.1.2)

Parameter	Average Large Mine	Average Mine
Average grade, percent U_3O_8	0.10	0.10
Th-232 concentration, pCi/g	10	10
Activity ratio (dust/ore)	2.5	2.5
Mineralogy	Sandstone	Sandstone
Density, MT/m^3	2.0	2.0
Surface area of stockpile, m^2	5,800	680
Stockpile height, m	3.1	3.1
Area of pad, m^2	5,480	620

Sub-Ore Parameters (3.4.1.3)

Parameter	Average Large Mine	Average Mine
Average grade, percent U_3O_8	0.035	0.035
Th-232 concentration, pCi/g	2	2
Activity ratio (dust/sub-ore)	2.5	2.5
Mineralogy	Sandstone	Sandstone
Density, MT/m^3	2.0	2.0
Surface area of dump, m^2	104,900	18,800
Dump height, m	12	6
Area of pad, m^2	99,400	17,700

Waste Rock Parameters (3.4.1.1)

Parameters	Average Large Mine	Average Mine
Average grade, percent U_3O_8	0.0020	0.0020
Th-232 concentration, pCi/g	1	1
Mineralogy	Sedimentary	Sedimentary
Density, MT/m^3	2.0	2.0
Surface area of dump, m^2	14,100	2,700
Dump height, m	12	6
Area of terrain, m^2	12,800	2,460

Wastewater Discharge Parameters (3.4.2.2)

Parameter (mg/ℓ except as noted)	Average Mine
Discharge volume, m^3/min	2.78 (assume value of 2.0)
Total Uranium	1.41
Radium-226, pCi/ℓ [a]	1.37
Lead-210, pCi/ℓ [a]	1.46
Total suspended solids	27.8
Sulfate [b]	116
Zinc	0.043
Barium	0.81
Cadmium	0.007
Arsenic	0.012
Molybdenum	0.29
Selenium	0.076

[a] Concentrations of Ra-226 and its daughters are reduced to 10 percent of the amount actually released due to irreversible sorption and precipitation.

[b] Concentrations of sulfate are reduced to 20 percent of the amount actually released due to irreversible sorption and precipitation.

Airborne Source Terms (3.4.4)

Section 3.4.4 identifies and describes potential sources of airborne contamination at underground mines. The principal sources are contaminated dusts due to mining operations and wind erosion and Rn-222 that is released from the mine exhaust vents during mining and from waste rock, sub-ore, and ore pile surfaces. Average annual emissions of contaminants from these sources during active mining operations are presented in the following tables of Section 3.4.4.

Source	Table
Combustion Products	3.52
Vehicular Dusts	3.56
Dust from Mining Activities	3.54
Wind Suspended Dust	3.55
Rn-222 Emissions	3.51

4.3 In Situ Leach Mine

The following parameters are for a model (hypothetical) in situ solution mine as defined in Section 3.5:

1. Size of deposit = 52.6 hectares
2. Average thickness of ore body = 8 m
3. Average ore grade = 0.06 percent U_3O_8
4. Mineralogy = Sandstone
5. Ore density = 2 MT/m^3
6. Ore body depth = 153 m
7. Mine life = 10 years (2-yr leach period in each of 5 sectors)
8. Well pattern = 5 spot
   - Injection wells = 260
   - Production wells = 200
   - Monitoring wells = 80
9. Annual U_3O_8 production = 227 MT
10. Uranium leaching efficiency = 80 percent
11. Lixiviant = Alkaline
12. Lixiviant flow capacity = 2,000 ℓ/min
13. Lixiviant bleed = 50 ℓ/min (2.5 percent)
14. Uranium in Lixiviant = 183 mg/ℓ
15. Calcite ($CaCO_3$) removal required = 2 kg calcite per kg U_3O_8

Data were insufficient to estimate aqueous releases of contaminants from these type mines. However, since these facilities are planned to operate with no aqueous discharges, releases of contaminants via this pathway, except for possible excursions, should be small. Annual releases of contaminants to the atmosphere were computed in Section 3.5.3 for the model mine and listed in Table 3.59. These estimated annual airborne releases will be used to compute dose and indicate adverse health effects that might be associated with in situ leach mining.

4.4 Inactive Surface Mine

The model inactive surface mine will be located in Wyoming. It is defined in Section 3.7.1. The model mine parameters are listed below.

Mine Parameters

1. Period of active mining = 17 years
2. Total waste rock production = 8.88×10^5 MT
3. Total ore production = 3.59×10^4 MT
4. Density of ore and waste rock = 2.0 MT/m^3
5. Size of abandoned pit:
   Volume = 4.62×10^5 m^3
   Ground surface area = 2.03×10^4 m^2
   Pit bottom area = 6.00×10^3 m^2
   Depth = 36.7 m
6. Surface area and composition of waste rock pile = 6.33×10^4 m^2 uniformly covered to a depth of 0.36 m with sub-ore
7. Reclamation = none

Airborne Source Terms

Sections 3.7.1.1 and 3.7.1.2 identify and describe potential sources of airborne contamination at inactive surface uranium mines. The principal sources are contaminated, wind-suspended dust from the waste rock pile and Rn-222 released from exposed ore and sub-ore bearing surfaces in the pit and the waste rock pile. Tables 3.70 and 3.74 show average annual emissions of contaminants from these sources.

4.5 Inactive Underground Mine

The model inactive underground mine will be located in New Mexico. It is defined in Section 3.7.2, and its parameters are listed below.

Mine Parameters

1. Period of active mining = 15 yrs
2. Total waste rock production = 1.00×10^4 MT
3. Total ore production = 3.14×10^4 MT
4. Density of ore and waste rock = 2.0 MT/m^3
5. Surface area and composition of waste rock pile = 4.08×10^3 m^2 uniformly covered to a depth of 0.78 m with sub-ore
6. Mine entrance and exhaust vents not sealed

Airborne Source Terms

Sections 3.7.2.1 and 3.7.2.2 identify and define potential sources of airborne contamination at inactive underground uranium mines. The principal sources are contaminated, wind-suspended dust from the waste rock pile and Rn-222 released from the unsealed mine entrance and exhaust vents and the waste rock pile. Tables 3.76 and 3.77 list average annual emission of contaminants from these sources.